

Claims 1-14 are pending in this application, with claims 1, 5, and 14 being independent claims. Claims 6-13 have been withdrawn from further consideration by the Examiner. Claims 1-5 are amended to more clearly define features of the present invention. Claims 14-18 are newly added. No new matter has been entered.

Applicant respectfully requests reconsideration and withdrawal of the objections and rejections set forth in the above-identified Office Action.

OBJECTION TO THE DRAWINGS

The drawings are objected by the Examiner because there are some foreign words in the drawings. In response, Applicant respectfully notes that corrected drawings were filed on April 23, 2001 in response to the Notice of Missing Parts dated October 24, 2000. The Applicant's record indicates, and has been confirmed by a return receipt, that the corrected drawings were received by the Patent Office on April 23, 2001.

Applicant respectfully requests the Examiner to look carefully in the application file for the corrected drawings. If the Examiner still cannot find the corrected drawings, Applicant is willing to provide an additional copy of the drawings.

Reconsideration and withdrawal of this objection is respectfully requested.

OBJECTION TO THE SPECIFICATION

The Examiner objected to specification because the title of the invention is not descriptive. In response, Applicant has amended the title to read --SEMICONDUCTOR DEVICE HAVING MULTILAYER INTERCONNECTION STRUCTURE AND METHOD OF MAKING THE SAME--. Reconsideration and withdrawal of this objection is respectfully requested.

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REJECTIONS UNDER 35 U.S.C. § 102

Claims 1 and 5 are rejected under 35 U.S.C. § 102(b) as being anticipated by Ueno (JP 10-209073). Also, claims 1 and 5 are rejected under 35 U.S.C. § 102(e) as being anticipated by Vitkavage et al. (U.S. Patent No. 5,858,873). Applicant respectfully traverses these rejections.

Independent claim 1 recites a semiconductor device comprising an insulator film formed on a substrate, a wiring layer of copper formed proximate the insulator film, and a crystalline film containing tungsten, carbon, and nitrogen for preventing copper diffusion from the wiring layer to the insulator film. The crystalline film is arranged between the insulator film and the wiring film. Independent claim 5 recites a semiconductor device comprising an insulator film formed on a substrate, a wiring layer of copper formed on the insulator film, and a crystalline film for preventing copper diffusion from the wiring layer to the insulator film. The crystalline film is formed of a material comprising tungsten, carbon, and nitrogen and arranged between the insulator film and the wiring layer. As will be described, the prior art cited by the Examiner does not teach or suggest the claimed invention because it fails to disclose each and every element of the claimed invention.

Ueno discloses a barrier layer of WSi_xN_y or WC_xN_y having an amorphous structure. As shown in Fig. 4, the WC_xN_y layer (15) is deposited on an oxide film (16), on which a copper layer (18) is deposited. Ueno, however, fails to disclose, *inter alia*, the barrier layer of WSi_xN_y or WC_xN_y (15) being a crystalline film as claimed. Instead, Ueno discloses the barrier layer (15) being an amorphous structure. Furthermore, the amorphous structure of Ueno is described in the Background of the Invention section (page 1, line 32 - page 2, line 4) of the present application along with the problem

associated with the amorphous structure. In contrast to the crystalline film of the claimed invention, the amorphous structure of the barrier layer crystallizes in response to temperature and deteriorates the barrier property of the barrier layer. That is, the crystalline film of the present invention is distinguished from the amorphous structure of Ueno. At least for these reasons, claims 1 and 5 are not anticipated by Ueno.

Vitkavage et al. discloses an integrated circuit having a contact in a recess (10) of a silicon substrate (2). The contact includes an adhesion layer (12) deposited on an inner surface of the recess (10), an amorphous layer of silicide (16) deposited over the adhesion layer (12) within the recess (10), and a central plug (18) composed of a conductive material. A refractory material layer (14) having a crystalline structure is deposited over the adhesion layer (12). Vitkavage et al. discloses that, while the refractory material layer (14) does not serve as a good boundary layer to prevent diffusion of aluminum-alloy into silicon, the non-crystalline amorphous layer (16) substantially prevents the conductive material from passing through the amorphous layer to contact the adhesion layer thereby to prevent junction leakage.

Vitkavage et al., however, fails to disclose, *inter alia*, the layer (14) (which may arguably be construed as a crystalline film for preventing copper diffusion from the wiring layer to the insulator film) being WC_xN_y film as claimed.

At least for this reason, claims 1 and 5 are not anticipated by Vitkavage et al. Thus, reconsideration and withdrawal of this ground of rejection.

Similar to claims 1 and 5, new independent claim 14 recites a semiconductor device comprising an insulator film formed on a substrate, a crystalline film formed on the insulator, and a wiring layer of copper formed on the crystalline film, wherein the

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crystalline film prevents copper diffusion from the wiring layer to the insulator film. None of the cited references teach or suggest the claimed invention. In particular, Vitkavage et al. does not disclose, *inter alia*, the metal plug (18) (which may arguably be construed as a wiring layer of copper) being formed on the crystalline film. As becomes apparent, Vitkavage et al. discloses the metal plug formed on a amorphous layer (16), rather than on the refractory material (14) (which arguably be construed as a crystalline film).

For the reasons set forth above, Applicant believes that new claim 14 is not anticipated by the cited prior art.

REJECTIONS UNDER 35 U.S.C. § 103

Claims 2-4 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Ueno (JP 10-209073). Also, claims 2-4 are rejected under 35 U.S.C. § 103(a) as being unpatentable over in view of Vitkavage et al. (U.S. Patent No. 5,858,873). Applicant respectfully traverses these rejections.

As fully discussed above, Ueno fails to disclose, *inter alia*, the barrier layer (15) being a crystalline film, and Vitkavage et al. fails to disclose, *inter alia*, the refractory material layer (14) being WC_xN_y film.

At least for these reasons, Applicant believes that the present invention, as claimed, is not rendered obvious over the cited prior art. Thus, Applicant respectfully requests reconsideration and withdrawal of these rejections.

CONCLUSION

Applicant respectfully requests the reconsideration and reexamination of this application and the timely allowance of the pending claims.

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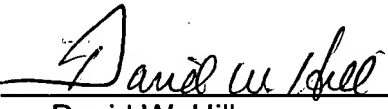
Attached hereto is a marked-up version of the changes made to the specification and claims 1-5 by this amendment.

Please grant any extensions of time required to enter this response and charge any additional required fees to our deposit account 06-0916.

Respectfully submitted,

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APPENDIX TO AMENDMENT

IN THE TITLE:

SEMICONDUCTOR DEVICE HAVING MULTILAYER INTERCONNECTION
STRUCTURE AND METHOD OF MAKING THE SAME--.

IN THE SPECIFICATION:

Paragraph beginning at line 11 of page 1 and ending at line 17 of page 1:

To achieve high integration of semiconductor devices, contrivances, such as miniscule patterning and multilayering of circuits, are under way. Among them is a technique for forming a multiplayer interconnection. To impart a multiplayer interconnection structure, an [nth] n^{th} wiring layer and an [n+1th] $(n+1)^{\text{th}}$ wiring layer are connected together by a conductor layer, and a thin film, called an interlayer insulator film, is formed in a region other than the conductor layer.

Paragraph beginning at line 28 of page 10 and ending at line 36 of page 10:

According to the results of analysis in FIG. 9, the horizontal axis represents the position in the depth direction of the sample, while the vertical axis represents the number of Cu ions etc. in a unit volume. From FIG. 9, it is seen that "Cu is present in the surface of the WCN film or halfway in the surface, but stops at a certain depth, and does not [exit] exist at a depth corresponding to the Si substrate." This outcome demonstrates that Cu does not diffuse into the Si substrate, and the barrier properties of the WCN film are high.

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IN THE CLAIMS:

1. (Amended) A semiconductor device comprising:

an insulator film formed on a substrate;

a wiring layer of copper formed [on] proximate the insulator film; and

a crystalline film containing tungsten, carbon, and nitrogen for preventing

copper diffusion [preventing film,] from the wiring layer to the insulator

film, the crystalline film arranged between the insulator film and the

wiring film[, that prevents copper diffusion from the wiring layer to the

insulator film].
2. (Amended) The semiconductor device according to claim 1, [wherein the copper
diffusion preventing film is a crystalline film, and] wherein the crystalline film,
when subjected to X-ray diffraction, [shows] has a spectrum having [peaks at] a
first peak [position] between 36 degrees and 38 degrees and [at] a second peak
[position] between 42 degrees and 44 degrees.
3. (Amended) The semiconductor device of claim 2, wherein [the copper diffusion
preventing film is the crystalline film that] a half-width of the first peak [at the first
position between 36 degrees and 38 degrees] is 3.2 degrees or less.
4. (Amended) The semiconductor device of claim 2, wherein [the copper diffusion
preventing film is the crystalline film that] a half-width of the second peak [at the
second position between 42 degrees and 44 degrees] is 2.6 degrees or less.
5. (Amended) A semiconductor device comprising:

an insulator film formed on a substrate;

a wiring layer of copper formed on the insulator film; and

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a crystalline film for preventing copper diffusion [preventing film that prevents copper diffusion] from the wiring layer to the insulator film, the crystalline [copper diffusion preventing] film [being] formed of a [film containing] material comprising tungsten, [and] carbon, and nitrogen, the crystalline film [and being] arranged between the insulator film and the wiring layer.

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